PROJECT REPORT ON

A Statistical Analysis on Automobile Sector

A REPORT SUBMITTED TO

DEPARTMENT OF STATISTICS
FACULTY OF SCIENCE
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

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CERTIFICATE

This is to certified that the project was entitled

"**A STATISTICAL ANALYSIS ON AUTOMOBILE SECTOR "** is bonafide work carried out by Sujit Raval , Saptarshi MT , Aesha Patel , Pinal Dabhi and Parth Parmar in partial fulfilment for partial award of **Master Of Science** in The Maharaja Sayajirao University Of Baroda , during the year 2020-21. It is certified that all correlations/suggestions indicated for the internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfied the academic requirements in respect of project work prescribed for the said Degree.

Signature of Guide	**Signature of the HOD**
Dr. Deepa Kandpal	**Prof. Vipul A. Kalamkar**

ACKNOWLEDGEMENT

We would like to express our profound gratitude to Dr. Deepa Kandpal for his constant support and encouragement throughout the Master's project work.

We are highly indebted to our Head: Prof. Vipul A. Kalamkar for his guidance and support as well as for providing necessary information regarding the project and helpful feedback.

Our thanks and appreciations also go to our colleagues in developing the project and people who have willingly helped us out with their abilities.

CONTENTS

Introduction

- The Automobile Industry in India is growing especially after 1991 Industrial policy.
- It contributes about 4 % in India's Gross Domestic Product(GDP) and 5 % in India's Industrial production.
- The Automobile Industry is supported by various factors such as availability of skilled labour at low cost, robust R&D centres, and low-cost steel production. The Industry also provides great opportunities for investment and direct and indirect employment to skilled and unskilled labour.
- Indian Automotive Industry (including component manufacturing) is expected to reach Rs. 16.16-18.18 trillion (US$ 251.4-282.8 billion) by 2026.
- Focus is shifting to electric vehicles to reduce emissions.
- Rise in middle class income and young population will drive strong growth.

- India was the world's fifth largest manufacturer of cars and seventh largest manufacturer of commercial vehicles in 2019.
- Indian Automotive Industry (including component manufacturing) is expected to reach Rs. 16.16-18.18 trillion (US$ 251.4-282.8 billion) by 2026.

- The Industry attracted Foreign Direct Investment (FDI) worth US$ 25.40 billion between April 2000 and December 2020 accounting for ~5% of the total FDI during the period according to the data released by Department for Promotion of Industry and Internal Trade (DPIIT).

- Domestic automobile production increased at 2.36% CAGR between FY16-FY20 with 26.36 million vehicles being manufactured in the country in FY20. Overall, domestic automobiles sales increased at 1.29% CAGR between FY16-FY20 with 21.55 million vehicles being sold in FY20.
- Two wheelers and passenger vehicles dominate the domestic Indian auto market. Passenger car sales are dominated by small and mid-sized cars. Two wheelers and passenger cars accounted for 80.8% and 12.9% market share, respectively, accounting for a combined sale of over 20.1 million vehicles in FY20. Two wheeler sales stood at 1,426,865 units in February 2021, compared with 1,294,787 units in February 2020, recording a rise of 10.20%.
- Passenger vehicle (PV) sales stood at 281,380 units in February 2021, compared with 238,622 units in February 2020, registering a growth of 17.92%. As per Federation of Automobile Dealers Associations (FADA), PV sales

in December 2020 stood at 271,249 units, compared with 218,775 units in December 2019, registering a 23.99% growth.

- Overall, automobile export reached 4.77 million vehicles in FY20, growing at a CAGR of 6.94% during FY16FY20. Two wheelers made up 73.9% of the vehicles exported, followed by passenger vehicles at 14.2%, three wheelers at 10.5% and commercial vehicles at 1.3%.

1.Commercial Vehicles:

The proportion of increased freight and passenger movement are the results of increased urbanization in towns and cities. Hence the importance of commercial vehicles cannot be under estimated. It comprises three sub divisions-the LCVs (light), MCVs (medium) and HCVs (heavy) commercial vehicles. India's $5 billion truck and bus market, in the world fifth largest has been enjoying a 30 per cent annual growth rate in the past three years13.

Heavy commercial vehicles transport bulk cargo over 500 km on an average consisting of industrial products and raw materials like iron and steel, cement, petroleum products, consumer goods, pharmaceuticals, agriculture commodities, electronics goods, industrial equipment and machinery.

2.*Multi Utility Vehicle Segment :*

In the last fifty years the MUVs market has grown tremendously from around 2000 vehicles in the late 1940 to around 181,000 vehicles in 2004-2005. This category of vehicles till the mid-80s

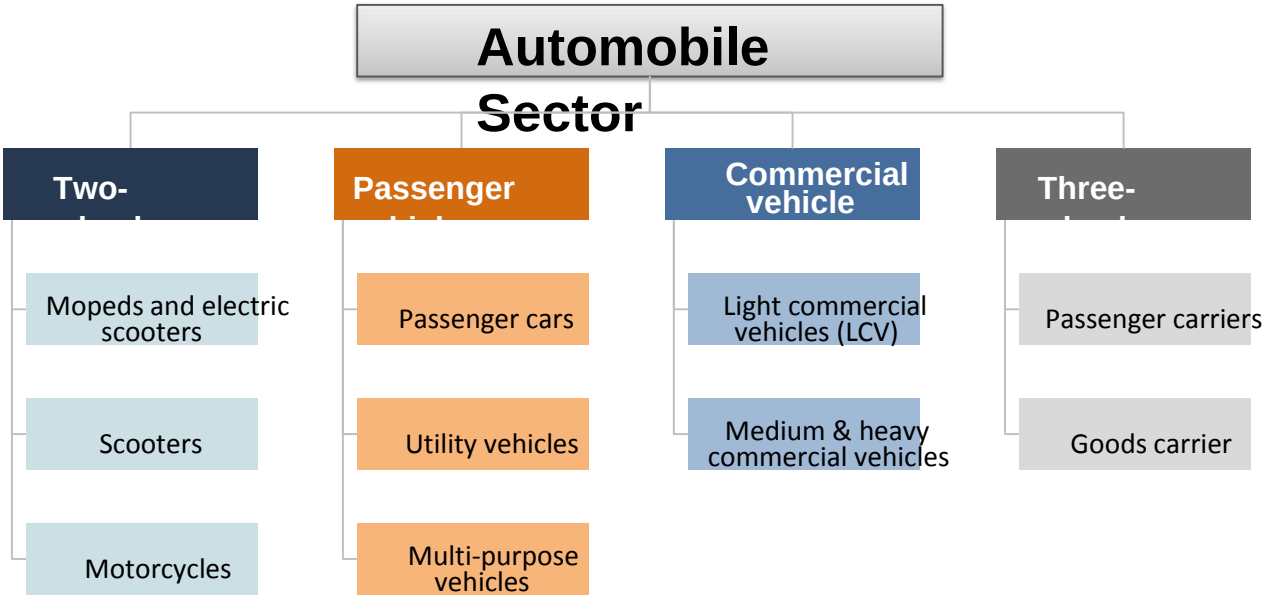
was primarily used by the government, army, police and Paramilitary forces exclusively are today an important mode of mass transport in rural and urban areas. These vehicles enjoy the benefits of some duties and concessions as commercial vehicles, which are substantially lower than those of passenger cars.

3.***Passenger Cars:***

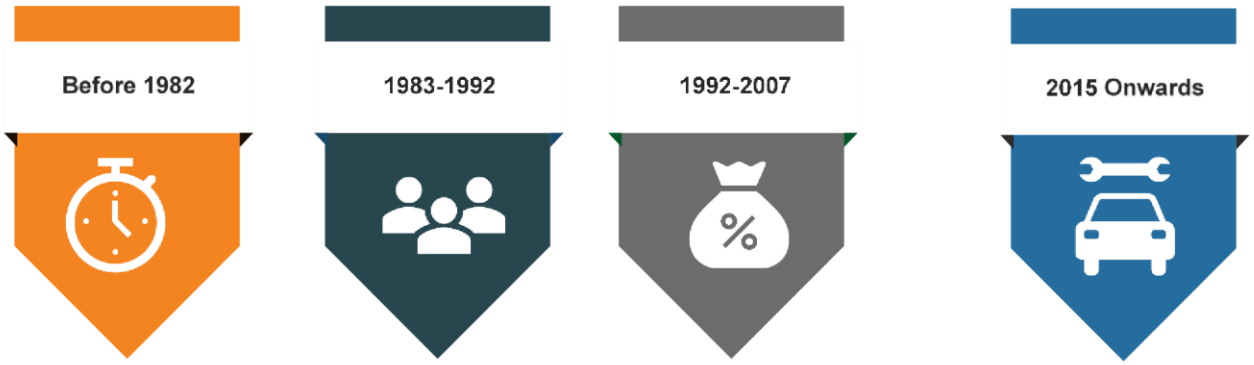
India is one of the oldest automotive industries in south and in south-East Asia, with the first passenger car made in the early 1940s. However, since then, the development of the industry shifted to two wheelers and LCVs. The industry profile in India is different from the global profile. Globally, passenger cars are the largest segment of the automobile industry, but in India it is much smaller. The Budget for 2006-07 has reduced the excise duty on small cars from 24 percent to 16 percent with the intention to become more price competitive in order to make India a hub for exporting small cars. India overtook China in 2004 as the fastest growing automobile market and closed the year with sales of a million passenger vehicles.

4.Two and Three Wheelers **:**

The two wheeler industry comprises of mopeds scooters, motor cycles .Scooters form the largest segment in the industry (37 percent) while the major part of the growth has come from motor cycles. Till mid 1980s scooters dominated the market but now motor cycles currently account for around two-third of the two wheeler market .The demand for two wheelers has come from rural areas. In these areas these vehicles are used as a means of carrying both passenger and goods.



Evolution of the sector :



Before 1982

- Closed market
- Long waiting periods & outdated models
- Seller's market

1983-1992

- Indian Government & Suzuki formed Maruti Udyog and commenced production in 1983.
- Component manufacturers entered the market via joint venture (JV).
- Buyer's market.

1992-2007

- Sector de-licensed in 1993.
- Major OEMs started assembly operations in India.
- Imports permitted from April 2001.
- Introduction of valueadded tax in 2005.

2015 Onwards

- Automotive Mission Plan 2016-26 launched in 2015.
- Bharat Stage (BS) IV emission norms since April 2017 and to adopt BSVI norms from 2020.
- 26.36 million vehicles produced in FY20.

Objectives

- Forecast the production of automobiles.
- Analysis the growth and trend in automobile sector over past decade.

ABOUT DATASET

YEAR	Passenger	Number of	GDP Per	GDP	EXPORT VOLUME (in 1000's)				Sales volume (in thousands)				PRODUCTION VOLUME(In Millions)				
	by road	Registred	Capita	(Billions $)													
	(In million	vehicles	($)		Passenger	Commercial	Two	Three	Commercial	Three	passenger	Two	Two	Three	passenger	Commercial	Production
	People	(In millions)			Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Vehicles	Total
	per Km)																
2011	8409	141.9	1458	1823.05	444.3	74.04	1531.6	269.97	683	532.1	2512	11830	13.35	0.8	2.98	0.76	17.89
2012	9478	159.5	1444	1827.64	508.78	92.26	1975.11	361.75	812.5	510.5	2605	13473	15.43	0.88	3.15	0.93	20.39
2013	10469	176	1450	1856.72	559.41	80.03	1956.38	303.09	791.6	542.4	2720	13800	15.74	0.84	3.23	0.83	20.64
2014	11472	190.7	1574	2039.13	596.14	77.05	2084	353.39	632.84	481.2	2500	14815	16.88	0.83	3.09	0.7	21.5
2015	13393	210	1606	2103.59	621.34	86.94	2457.47	407.6	614.92	532.6	2601.23	15975	18.49	0.95	3.22	0.7	23.36
2016	15428	230	1733	2294.12	653.05	103.12	2482.88	404.44	685.7	538.2	2789.2	16455	18.83	0.93	3.41	0.78	23.95
2017	17832	253.3	1982	2652.76	758.73	108.27	2340.28	271.89	714.08	511.9	3048	17590	19.93	0.78	3.8	0.81	25.32
2018	20685	278.63	2006	2713.17	748.37	96.87	2815	381	856.92	635.7	3288.5	20200	23.15	1.02	4.01	0.89	29.07
2019	23994	306.5	2100	2868.93	676.19	99.93	3280.84	576.68	1007.32	701	3377.3	21179	24.5	1.27	4.03	1.11	30.91
2020	27833	337.15	1877	2590	677.31	60.71	3520.38	502.17	717.69	636.5	2773.5	17417	21.04	1.13	3.43	0.75	26.35

- Following data we will analysis for Time series method.

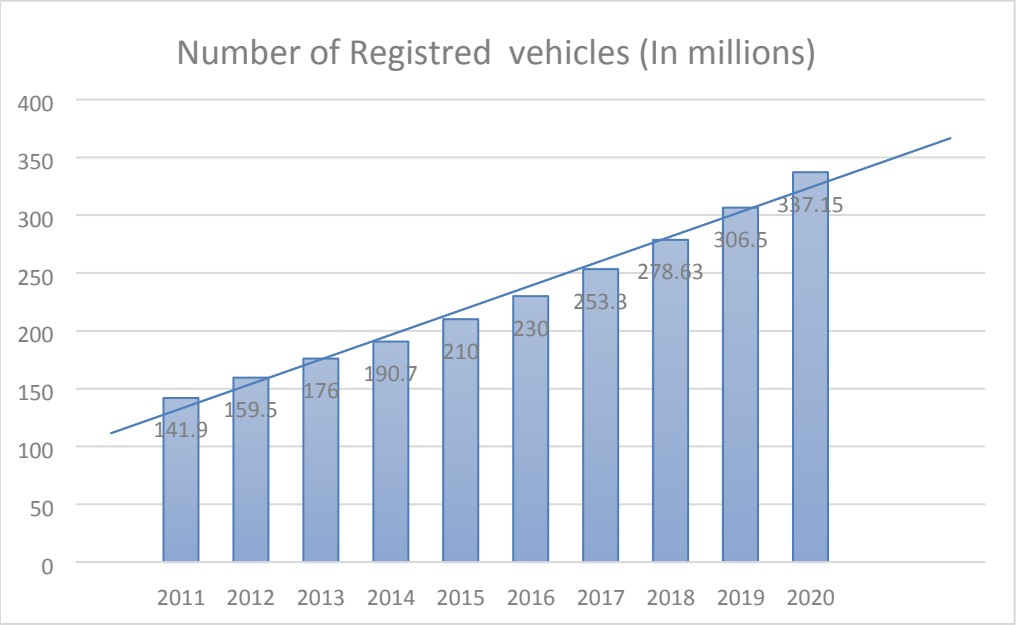
Graphical Representation

(1).Registered Motor Vehicles in India (in millions) 2011-2020

YEAR	Number of Registered vehicles (in millions)
2011	141.9
2012	159.5
2013	176
2014	190.7
2015	210
2016	230
2017	253.3
2018	278.63
2019	306.5
2020	337.15

The total no. of registered vehicles increased from about 141.9 million in 2011 to 337.15 as on 2020.

A graphic representation of the total no. of all registered vehicles in India since 2011 to 2020 may be seen in chart below:

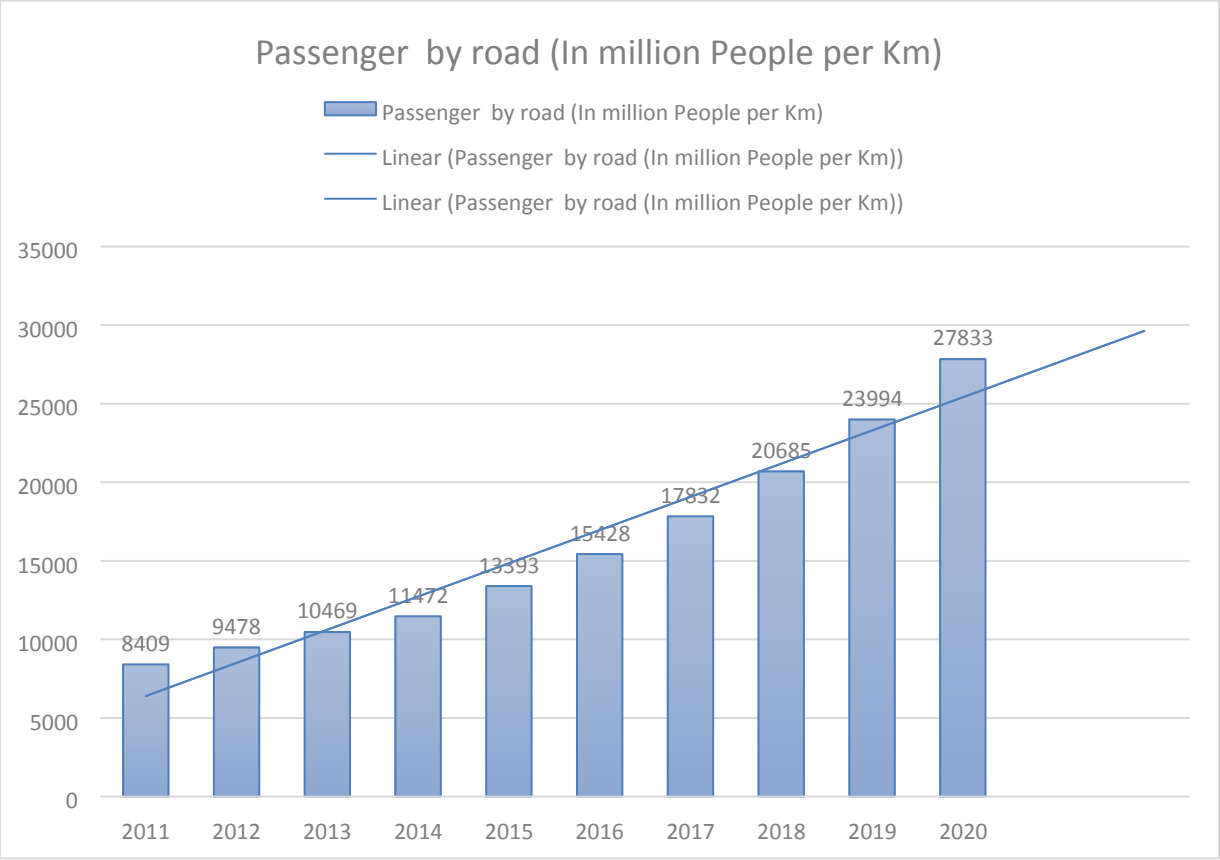


Conclusion :

There has been increase in the no. of registered motor vehicles in India since 2011.

(2).Number of Passengers by Road (in billion people per km) 2011 -2020

YEAR	Passenger by road (in billion people per km)
2011	8409
2012	9478
2013	10469
2014	11472
2015	13393
2016	15428
2017	17832
2018	20685
2019	23994
2020	27833



Conclusion :

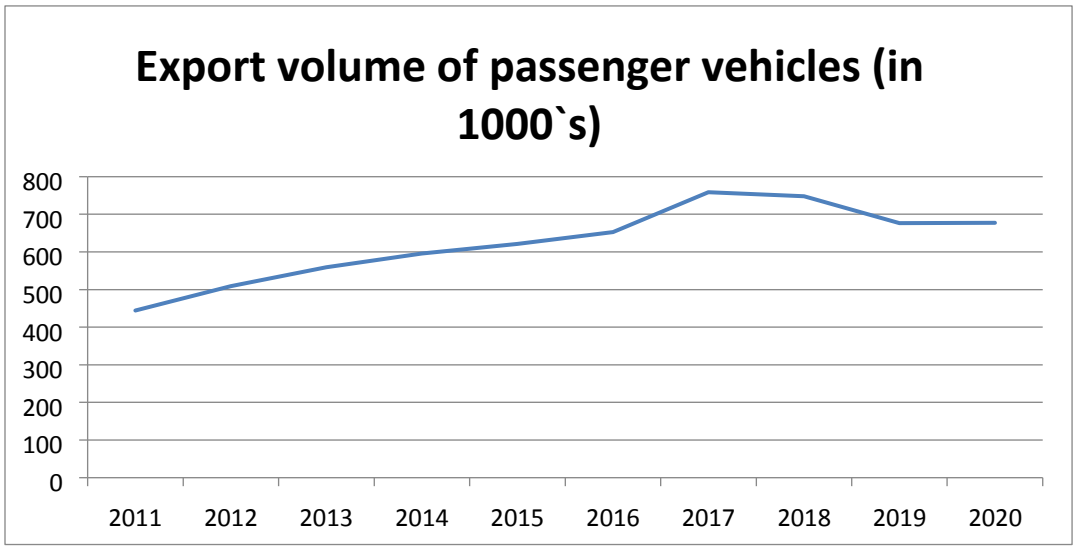
There has been also a continuous increase in the Passenger by road in India since 2011.

(3). Export Volume of Vehicles(in 1000's) 2011-2020

YEAR	Export Volume of Vehicles (in 1000's)			
	passenger vehicles	commercial vehicles	two wheelers	three wheelers
2011	444.3	74.04	1531.6	269.97

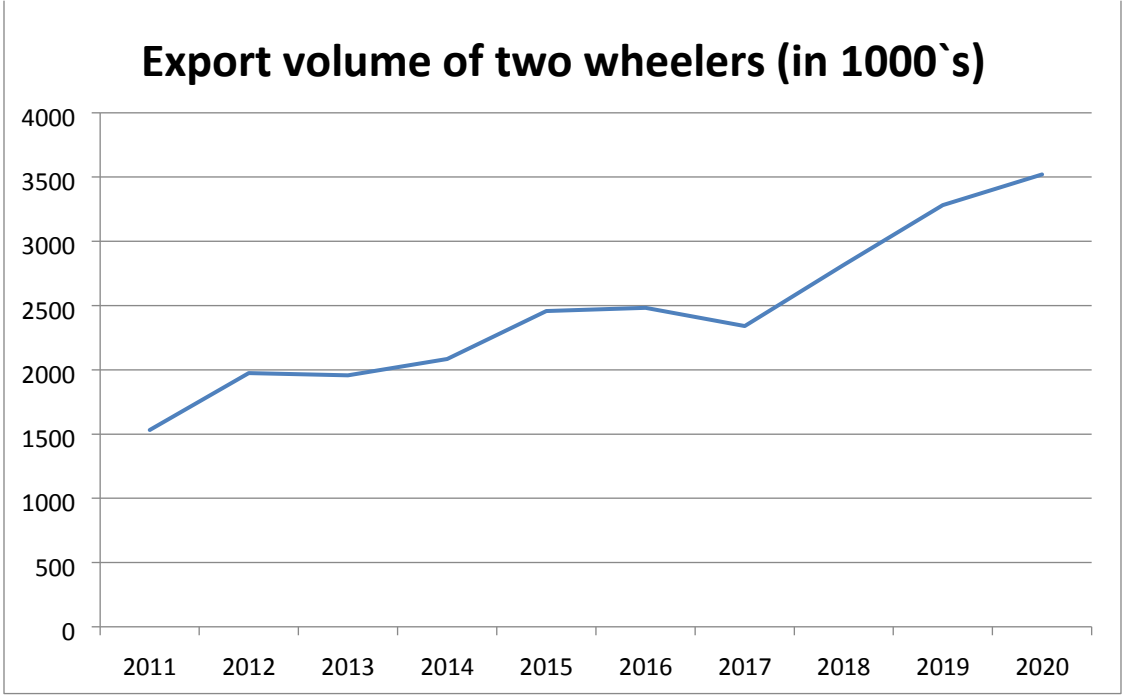
2012	508.78	92.26	1975.11	361.75
2013	559.41	80.03	1956.38	303.09
2014	596.14	77.05	2084	353.39
2015	621.34	86.94	2457.47	407.6
2016	653.05	103.12	2482.88	404.44
2017	758.73	108.27	2340.28	271.89
2018	748.37	96.87	2815	381
2019	676.19	99.93	3280.84	576.68
2020	677.31	60.71	3520.38	502.17

(i).



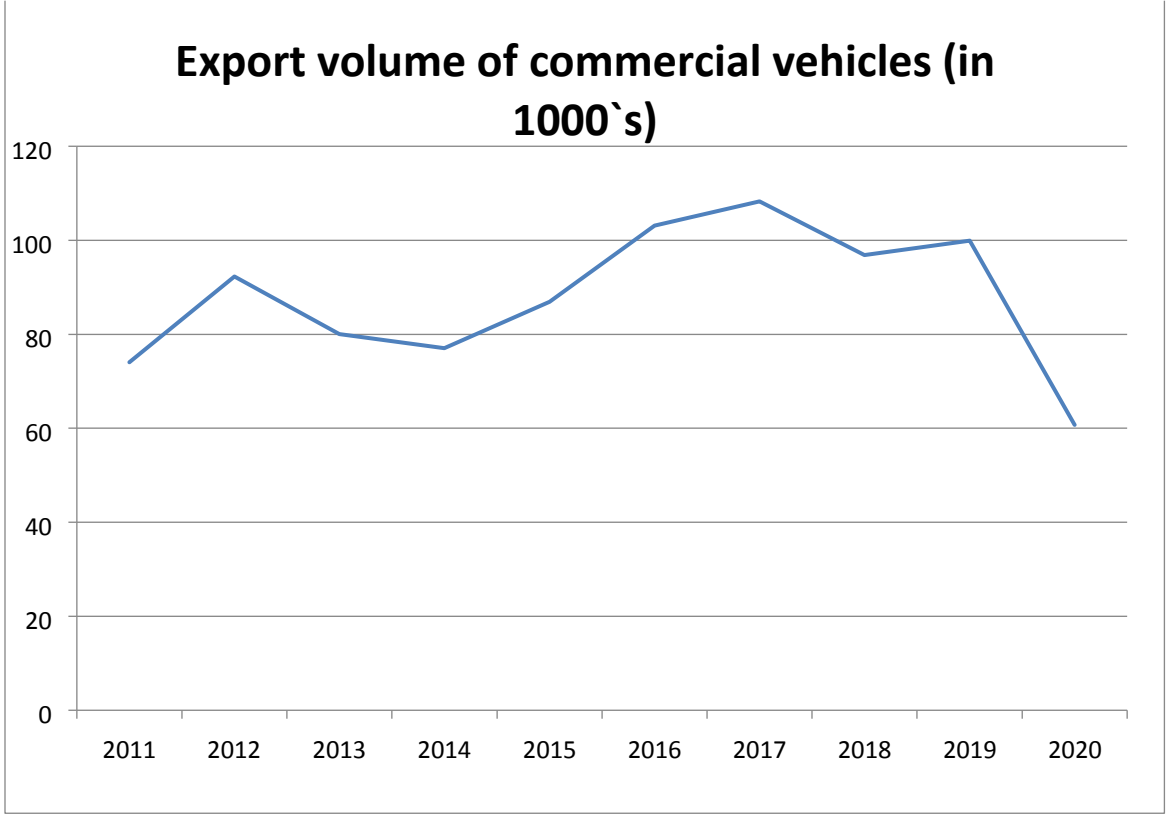
- **Exports grew at 5.4% between 2011 to 2019.**
- **While it grew by just 1% in 2020.**

(ii).



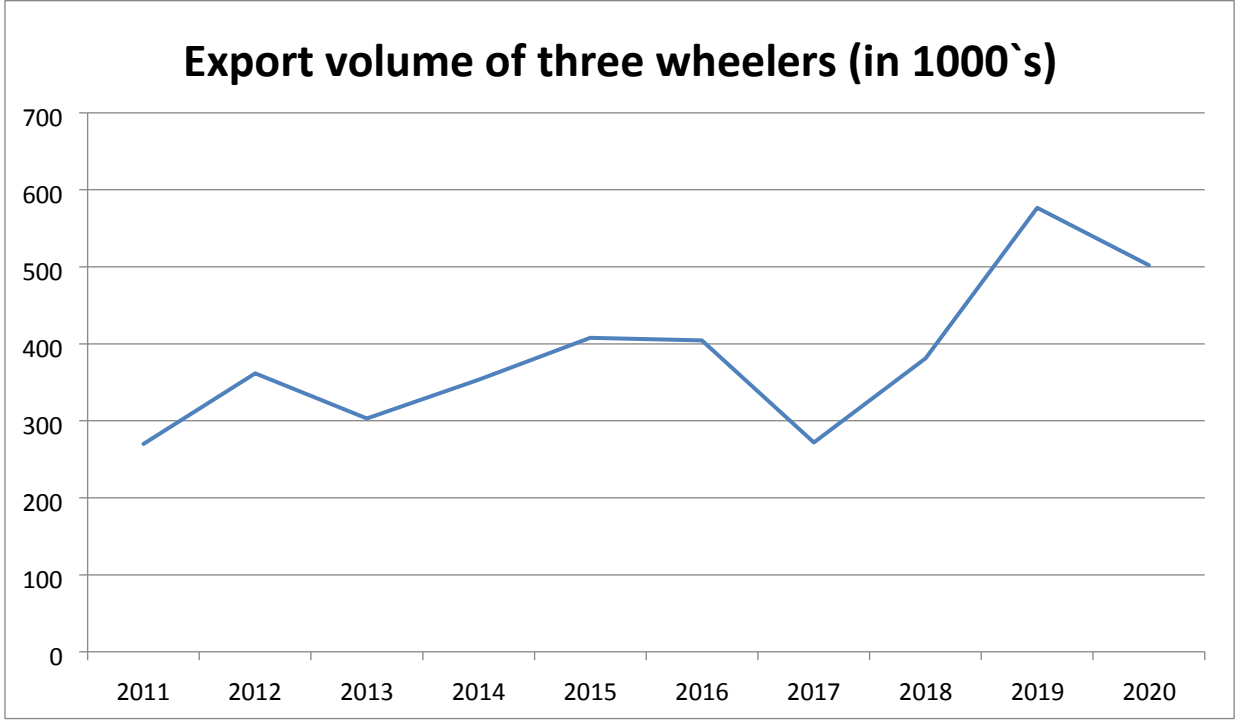
- **Exports grew at almost 10% between 2011 to 2019.**
- **While it grew by 7% in 2020**

(iii).

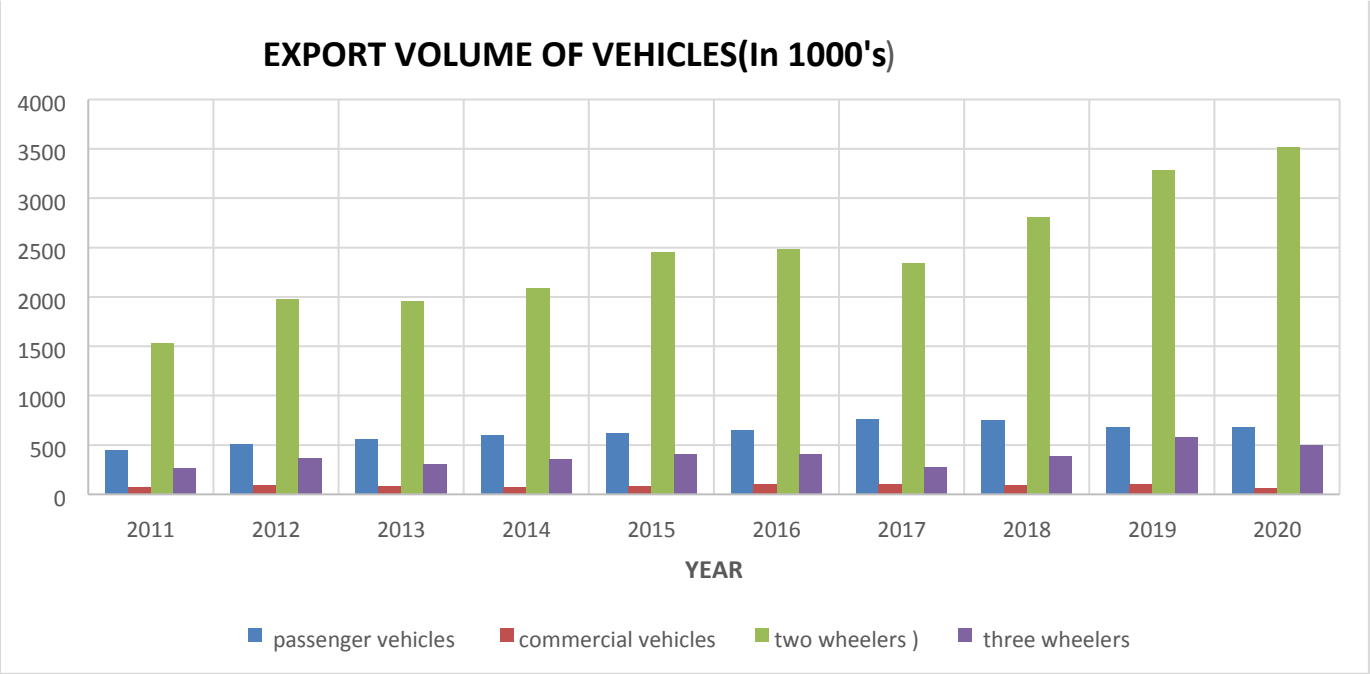


- **Export grew by 3.8% between 2011 to 2015.**
- **whlie it fell by 39% in 2020.**

(iv).



- **Export grew by 9.9 %.**
- **While it fell by 12%.**

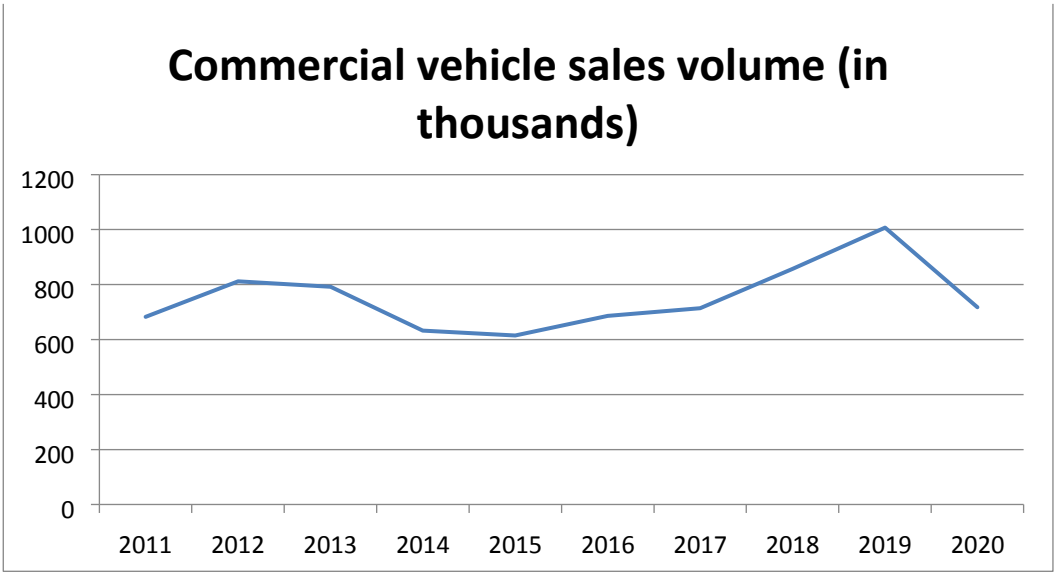


(4).Sales volume of vehicles(in thousands) 2011-2020

YEAR	Sales volume of Vehicles(in thousands)			
	Passenger vehicles	commercial vehicles	two wheelers	three wheelers

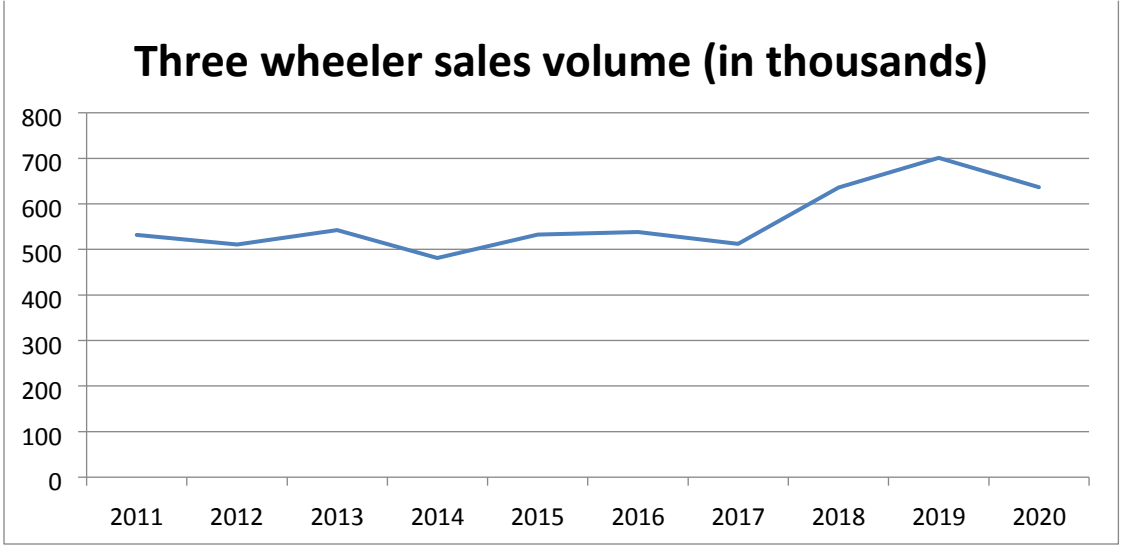
2011	2512	683	11830	532.1
2012	2605	812.5	13473	510.5
2013	2720	791.6	13800	542.4
2014	2500	632.84	14815	481.2
2015	2601.23	614.92	15975	532.6
2016	2789.2	685.7	16455	538.2
2017	3048	714.08	17590	511.9
2018	3288.5	856.92	20200	635.7
2019	3377.3	1007.32	21179	701
2020	2773.5	717.69	17417	636.5

(i).



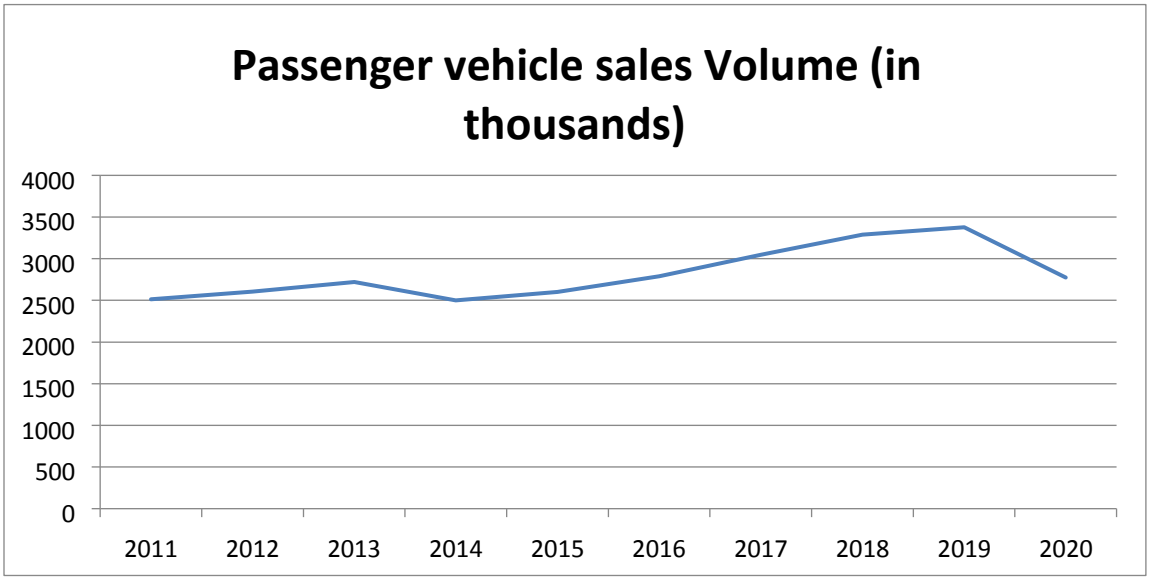
- Sales grew by 4.9 % between 2011 to 2019.
- while it fell by 28% in 2020.

(ii).



- sales grew by 3.5 % while.
- While it fell by 9.2 %

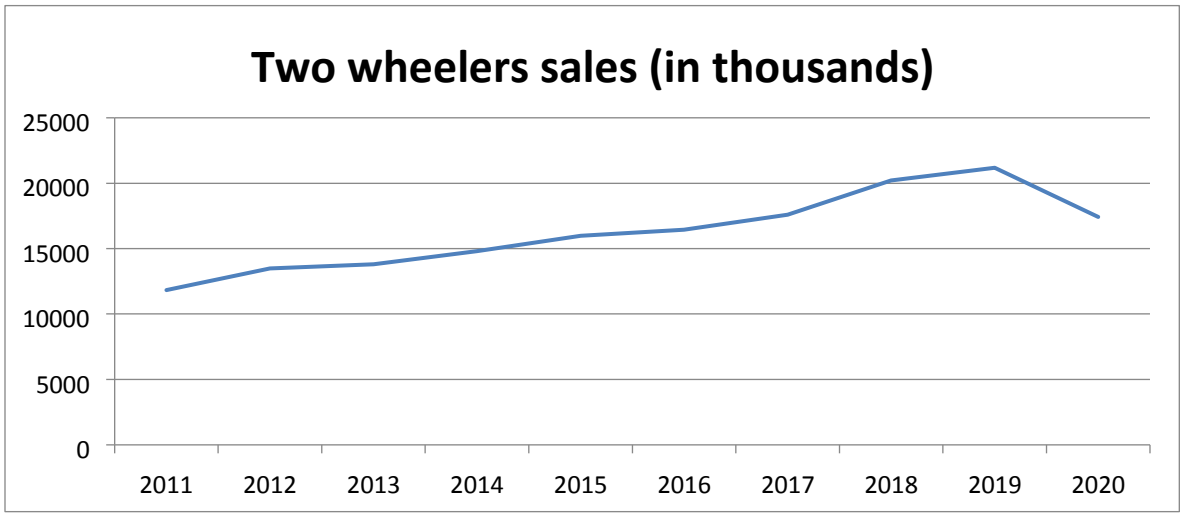
(iii).



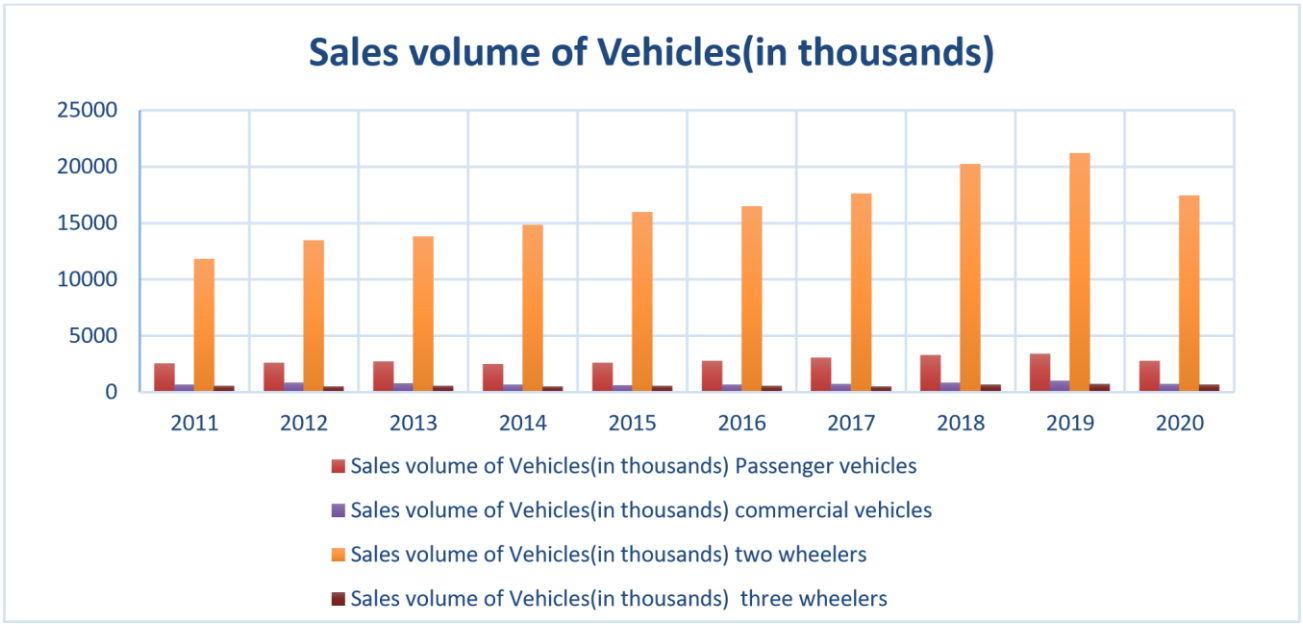
- Sales grew by 3.78 %

- While it fell by 17.8 %

(iv).



- sales grew by 7.5 %.
- While it fell by 17.7 % in 2020



Statistical Analysis

Holtz Method

Holt's two-parameter model, also known as linear exponential smoothing, is a popular smoothing model for forecasting data with trend. Holt's model has three separate equations that work together to generate a final forecast. The first is a basic smoothing equation that directly adjusts the last smoothed value for last period's trend. The trend itself is updated over time through the second equation, where the trend is expressed as the difference between the last two smoothed values. Finally, the third equation is used to generate the final forecast. Holt's model uses two parameters, one for the overall smoothing and the other for the trend smoothing equation. The method is also called double exponential smoothing or trendenhanced exponential smoothing.

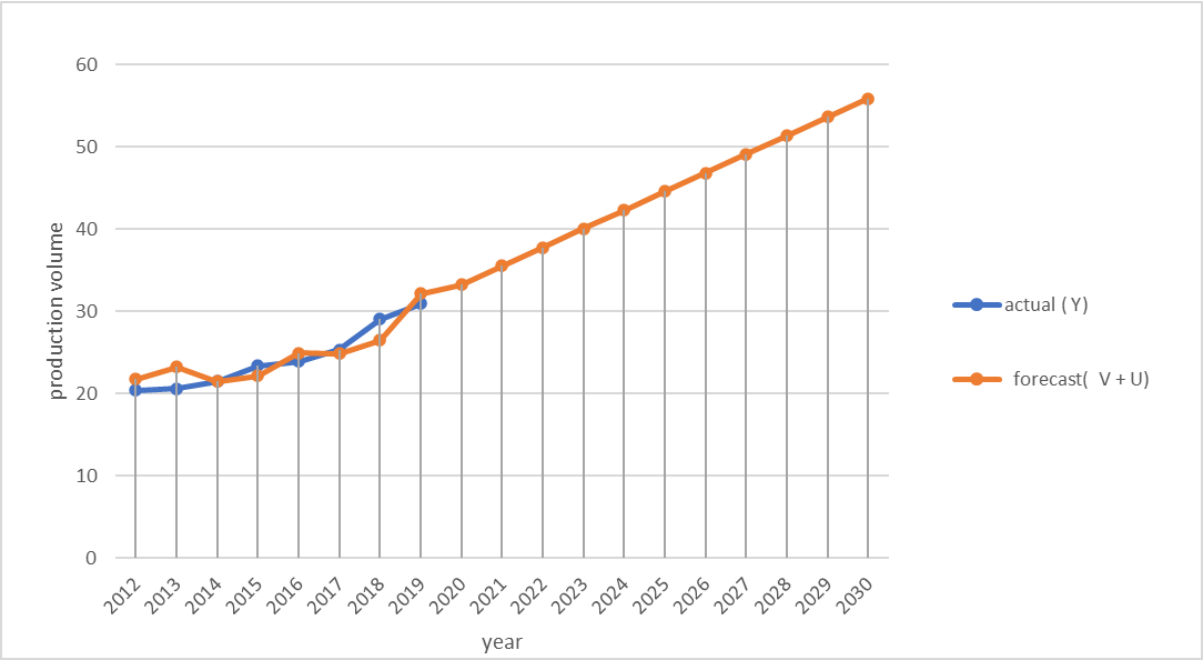
Level equation $V(i) = \text{alpha} * Y(i) + (1 - \text{alpha}) * [\, V(i-1) + U(i-1) \,]$

Trend equation $U(i) = \text{beta} * [\, V(i) - V(i-1) \,] + (1 - \text{beta}) * U(i-1)$

Forecast equation $= V(i-1) + U(i-1)$

where $0 < \textit{alpha} \leq 1$ and $0 \leq \textit{beta} \leq 1$.

						holts method on production volume(in millions)		
time	**actual (Y)**	**V**	**U**	**forecast(V + U)**				
2010	14							**|error|**
2011	17.89	17.89	3.89					
2012	20.39	20.48136	2.780474	21.78				0.0681707
2013	20.64	20.81233	0.68767	23.26183668				0.127027
2014	21.5	21.5	0.68767	21.50000019				8.647E-09
2015	23.36	23.28294	1.623448	22.18766964				0.0501854
2016	23.95	24.01286	0.860036	24.90639177				0.0399329
2017	25.32	25.29061	1.216922	24.8728988				0.017658
2018	29.07	28.90157	3.262334	26.50753411				0.0881481
2019	30.91	30.99242	2.261441	32.16390631				0.0405664
2020			1	33.25385851				
2021			2	35.51529915			**total error percent**	5.3961048
2022			3	37.77673979				
2023			4	40.03818043				
2024			5	42.29962107				
2025			6	44.56106171				
2026			7	46.82250235				
2027			8	49.08394299				
2028			9	51.34538363				
2029			10	53.60682427				
2030			11	55.86826491				
		alpha	**beta**					
		0.934271	0.854378					



time	PRODUCTION VOLUME --->>> (in millions)	2 wheelers	3 wheelers	passenger	commercial
2011	17.89	13.35	0.8	2.98	0.76
2012	20.39	15.43	0.88	3.15	0.93
2013	20.64	15.74	0.84	3.23	0.83
2014	21.5	16.88	0.83	3.09	0.7
2015	23.36	18.49	0.95	3.22	0.7
2016	23.95	18.83	0.93	3.41	0.78
2017	25.32	19.93	0.78	3.8	0.81
2018	29.07	23.15	1.02	4.01	0.89
2019	30.91	24.5	1.27	4.03	1.11
	proportional average ---------->>>	0.77828123	0.03929529	0.14665522	0.035768259
	Forecast:				
2020	33.25385851	25.8808539	1.30671996	4.87685203	1.18943263
2021	35.51529915	27.6408907	1.39558392	5.20850411	1.270320425
2022	37.77673979	29.4009275	1.48444788	5.54015619	1.35120822
2023	40.03818043	31.1609643	1.57331185	5.87180827	1.432096015
2024	42.29962107	32.9210011	1.66217581	6.20346035	1.51298381
2025	44.56106171	34.6810379	1.75103977	6.53511243	1.593871605
2026	46.82250235	36.4410747	1.83990373	6.86676451	1.6747594

2027	49.08394299	38.2011115	1.92876769	7.19841659	1.755647195
2028	51.34538363	39.9611483	2.01763166	7.53006867	1.83653499
2029	53.60682427	41.7211851	2.10649562	7.86172075	1.917422785
2030	55.86826491	43.4812219	2.19535958	8.19337283	1.99831058

The production of vehicles will consistently grow in the coming decade.

2 wheelers will have the maximum production followed by passenger vehicles then 3 wheelers and commercial vehicles.

The government aims to have 30 % of the automobile sales to constitute of electric vehicles by the year 2030.

So in the year 2030, we calculated the electric sales for various segments :

2 wheelers = sales in 2030 * 30% , 3 wheelers = sales in 2030 * 30% , 4 wheelers = sales in 2030 * 30%.

Then we calculated CAGR from 2019 to 2030 the formula :

= (sales in 2030 / sales in 2019) ^ (1/n) – 1. Where n = 11 years.

After that we calculated the sales for every year assuming the CAGR.

The government aims to have 30 % of the automobile sales to constitute of electric vehicles by the year 2030.

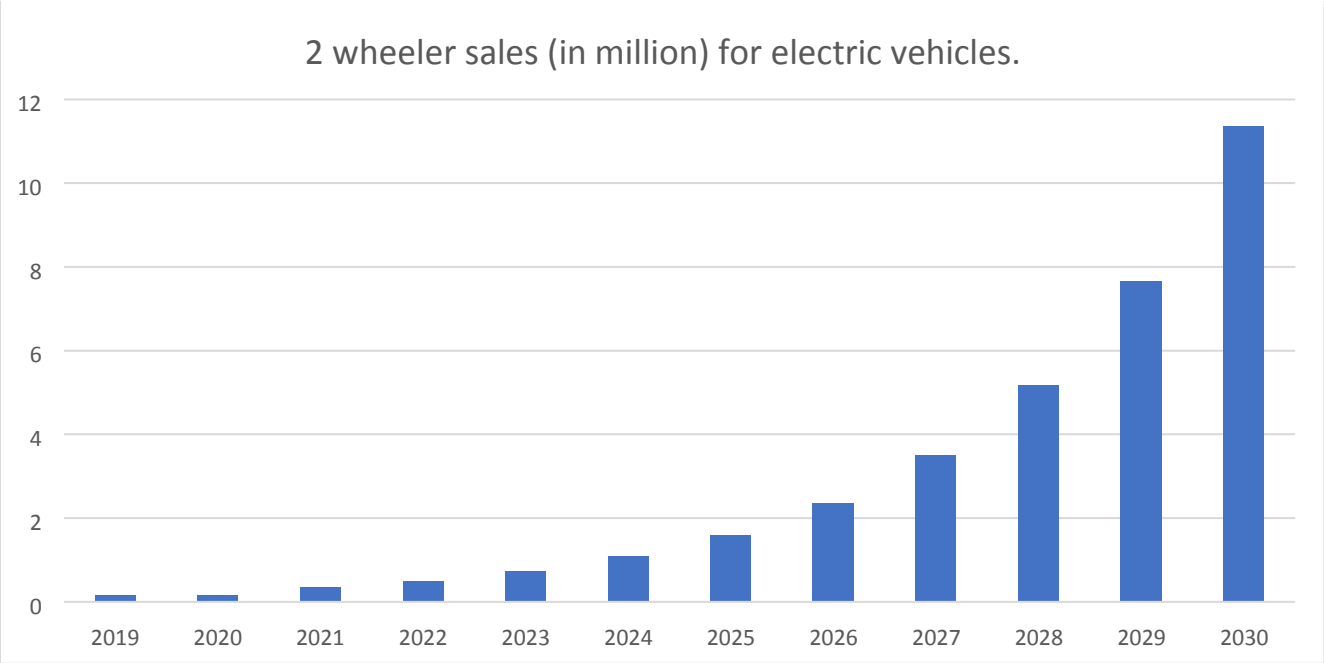
For that aim to be achieved the sales of:

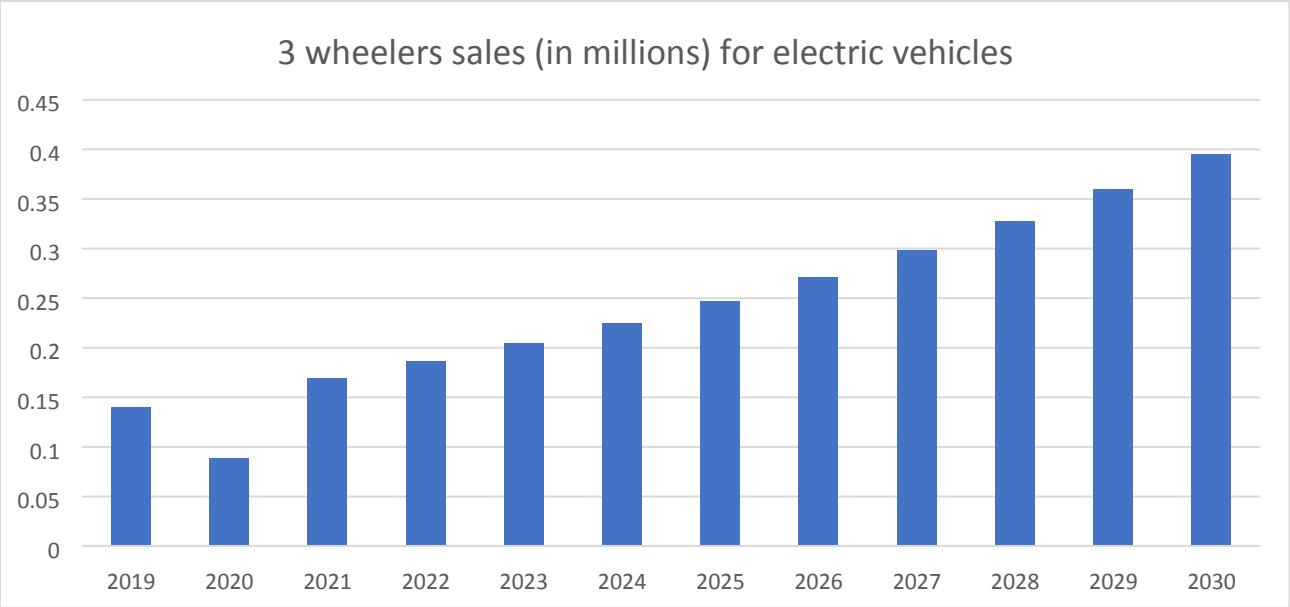
2 wheeler needs to grow annually at 49.80%.

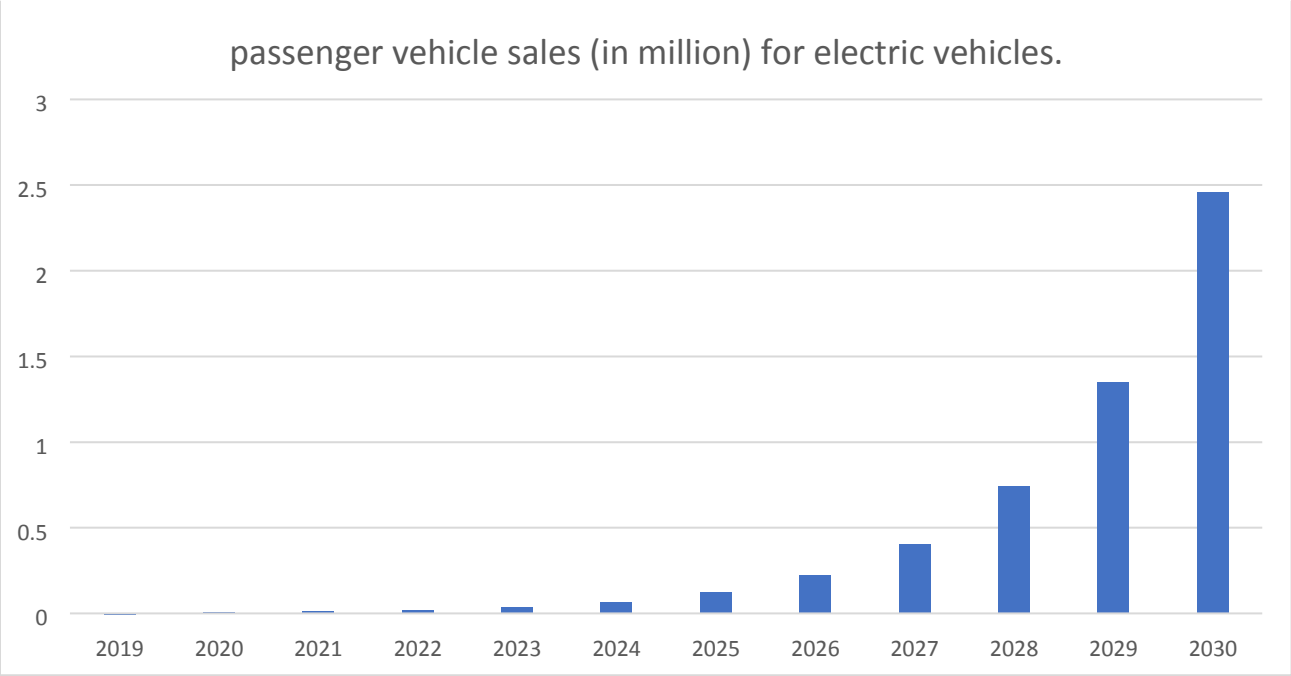
3 wheeler needs to grow annually at 15.1%.

Passenger vehicle sales need to grow annually at 81.90 %.

	ELECTRIC VEHICLE SALES VOLUME (in millions)				
	(30 % in 2030 by NITI AYOG)				
YEAR	**2W**	**3W**	**passenger**		
2019	0.152	0.14	0.0034		
2020	0.143837	0.088378	0.005905		
2021	0.341089	0.185472	0.01125		
2022	0.510951	0.213478	0.020463		
2023	0.765404	0.245714	0.037223		
2024	1.146575	0.282816	0.067708		
2025	1.71757	0.325522	0.123162		
2026	2.57292	0.374676	0.224031		
2027	3.854234	0.431252	0.407512		
2028	5.773643	0.49637	0.741265		
2029	8.648917	0.571322	1.34836		
2030	13.04437	0.658608	2.458012		
CAGR =	49.80%	15.10%	81.90%		


2 wheeler sales (in million) for electric vehicles.
12
10
8
6
4
2
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030


3 wheelers sales (in millions) for electric vehicles
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030



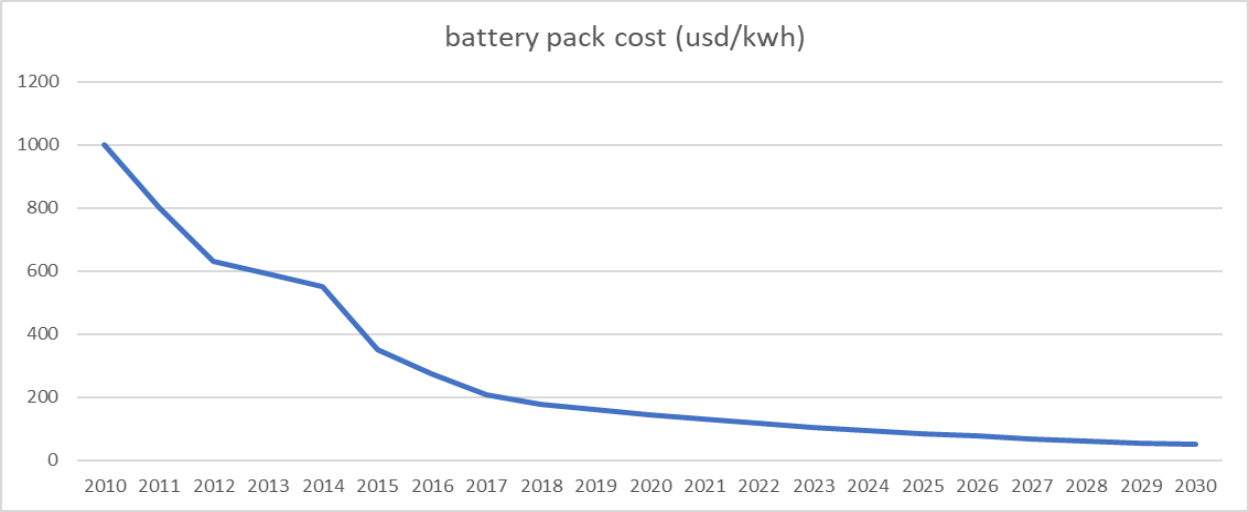
Uptill 2019 the cost of battery pack was $168. Industry estimates forecasted that by 2030, the cost of battery pack will be $50.

Hence we applied the formula of CAGR. And then we estimated the cost of battery pack over the next decade.

Annually the cost of battery pack reduced at 10 % rate.

YEAR	battery pack cost (usd/kwh)
2010	1000
2011	800
2012	630
2013	590
2014	550
2015	350
2016	273
2017	209
2018	178
2019	160
2020	144
2021	130
2022	117
2023	105
2024	95
2025	86
2026	77
2027	69

2028	62
2029	56
2030	50



In 2019 a typical :

2 wheeler uses 2 GW of battery.

3 wheeler uses 4 GW of battery.

Passenger vehicle uses 20 GW of battery.

Assuming the cost of battery pack reduces over the years as calculated above ; manufacturers use the reduced cost to increase the battery size in the vehicle we arrive at the conclusion :

Formula used = (Battery pack of vehicle in 2019) x ($160) / (cost of battery pack in the respective year)

YEAR	**battery pack cost (usd/kwh)**		**2 w battery pack (GWh)**	**4 w battery pack (GWh)**	**3 w battery pack (GWh)**
2019	160		3	21	4
2020	144		3.333333	23.33333	4.444444
2021	130		3.692308	25.84615	4.923077
2022	117		4.102564	28.71795	5.470085
2023	105		4.571429	32	6.095238
2024	95		5.052632	35.36842	6.736842
2025	86		5.581395	39.06977	7.44186
2026	77		6.233766	43.63636	8.311688
2027	69		6.956522	48.69565	9.275362
2028	62		7.741935	54.19355	10.32258
2029	56		8.571429	60	11.42857
2030	50		9.6	67.2	12.8

Over the year it increases.

Then we proceed to calculate the overall industry battery requirement for the country.

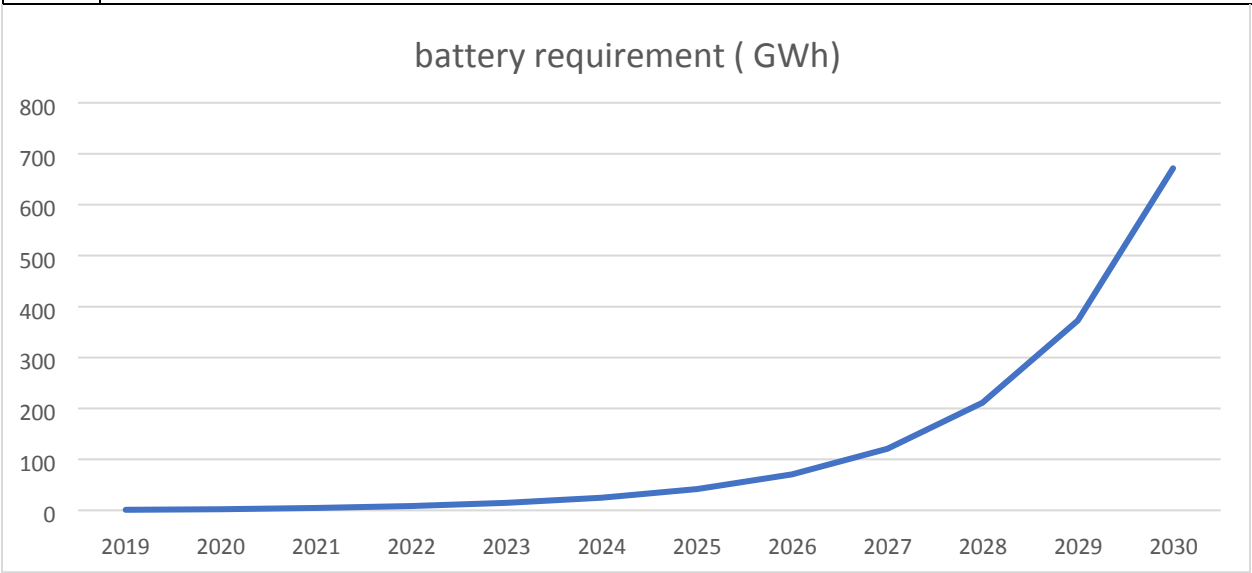
We do it by simply :

= (battery capacity of the vehicle) x (sales volume of that vehicle in the respective year)

The sales volume we already calculated before. It is again shown below.

	ELECTRIC VEHICLE SALES VOLUME (in millions)				
	(30 % in 2030 by NITI AYOG)				
YEAR	**2W**	**3W**	**passenger**		
2019	0.152	0.14	0.0034		
2020	0.143837	0.088378	0.005905		
2021	0.341089	0.185472	0.01125		
2022	0.510951	0.213478	0.020463		
2023	0.765404	0.245714	0.037223		
2024	1.146575	0.282816	0.067708		
2025	1.71757	0.325522	0.123162		
2026	2.57292	0.374676	0.224031		
2027	3.854234	0.431252	0.407512		
2028	5.773643	0.49637	0.741265		
2029	8.648917	0.571322	1.34836		
2030	13.04437	0.658608	2.458012		
CAGR =	49.80%	15.10%	81.90%		

		Battery requirement (GWh)			
YEAR	**2 w**	**4 w**	**3 w**	**SUM (2w + 3w + 4w)**	**Cummulative**
2019	0.456	0.0714	0.56	1.0874	1.0874
2020	0.479457	0.137783	0.3927911	1.010031111	2.097431111
2021	1.259404	0.290764	0.9130936	2.463261439	4.56069255
2022	2.096208	0.587666	1.1677453	3.851619235	8.412311786
2023	3.498991	1.191131	1.4976834	6.187805443	14.60011723
2024	5.793224	2.394738	1.9052897	10.09325169	24.69336892
2025	9.586438	4.811893	2.4224873	16.82081769	41.5141866
2026	16.03898	9.775891	3.114186	28.92905905	70.44324566
2027	26.81206	19.84407	4.000014	50.65614513	121.0993908
2028	44.69917	40.17175	5.1238243	89.99474823	211.094139
2029	74.13357	80.90161	6.5293992	161.5645809	372.6587199
2030	125.2259	165.1784	8.4301808	298.8344962	**671.4932162**
	total battery requirement (GWh) = 671 GWh by the end of 2030.				



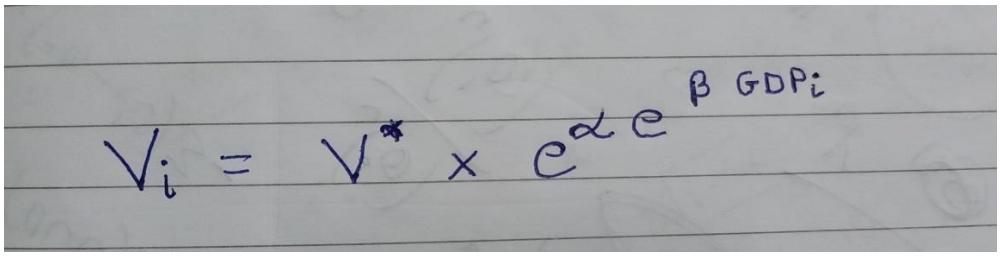
We see that by the year 2030 the battery requirement of the entire country will be between 600 to 1000 GWh.

The government will need to invest highly and provide subsidies to private players to install Giga factories and keep up with demand.

Gompertz Method

The Gompertz curve or Gompertz function is a type of mathematical model for a time series, named after Benjamin Gompertz (1779–1865). It is a sigmoid function which describes growth as being slowest at the start and end of a given time period. The right-hand or future value asymptote of the function is approached much more gradually by the curve than the left-hand or lower valued asymptote. This is in contrast to the simple logistic function in which both asymptotes are approached by the curve symmetrically. It is a special case of the generalised logistic function.

The Gompertz function is widely applied to establish the relationship between vehicle ownership and economic factors . The Gompertz function is used here to estimate country-level vehicle ownership as follows :



where

i different years;

V(i) represents the vehicle ownership (vehicles per 1000 people) ;

Vi * represents the ultimate saturation level of vehicle ownership (vehicles per 1000 people) of country .

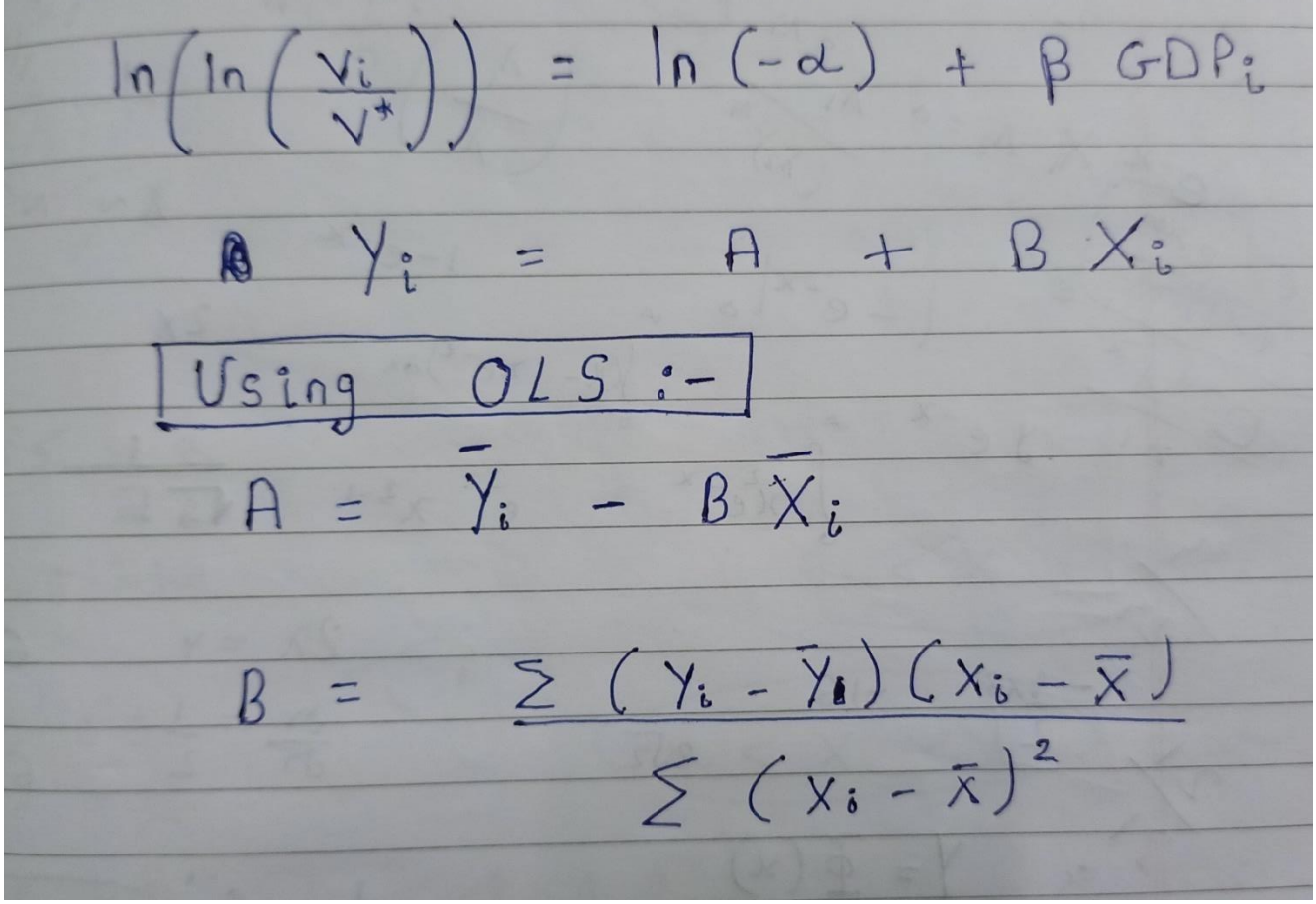
Given the parameters of α and β,

V(i) changes in proportion to the change of Vi* GDP(i) represents the economic factor (per capita GDP).

α and β are two negative parameters that determine the shape of the S-curve.

The increase of α and β would lead to a steep S-shape curve against the economic factors.

Log-linearization :



ln (−α) and β were linearly related and could be regressed as OLS for time series data of country.

Now we will calculate the 2 wheeler and Passenger vehicle ownership.

Data of GDP, Population, vehicles were available till 2019.

We projected GDP uptill 2041. GDP will grow at 8 % from 2021 to 2030. And then at 6 % from 2030 to 2041.

Population will reach 1.5 billion till 2030 and 1.6 billion till 2041. We calculated it by decrease rate of growth method.

GDP per capita (Xi) = (GDP) / (Population).

year	gdp (in billion US $)	population(in millions)	gdp per capita(US $) ----- (X(i))
2001	915.488	1075	851.6167442
2002	950.313	1093	869.4537969
2003	1025	1111.5	922.177238
2004	1106	1129.6	979.1076487
2005	1194	1147.6	1040.432206
2006	1290	1165.5	1106.821107
2007	1389	1183.2	1173.935091

2008	1432	1200.6	1192.736965
2009	1544	1217.7	1267.964195
2010	1676	1234.3	1357.854654
2011	1763	1250.3	1410.061585
2012	1860	1265.8	1469.42645
2013	1978	1281	1544.106167
2014	2125	1296	1639.660494
2015	2295	1310.15	1751.70782
2016	2484	1324	1876.132931
2017	2653	1338	1982.810164
2018	2827	1352	2090.976331
2019	2941	1367	2151.426481
2020	2700	1378	1959.361393
2021	3049	1391	2191.948239
2022	3292.92	1405	2343.715302
2023	3556.3536	1418	2508.00677
2024	3840.861888	1431	2684.040453
2025	4148.130839	1443	2874.657546
2026	4479.981306	1456	3076.910238
2027	4838.379811	1468.5	3294.776854
2028	5225.450196	1481.1	3528.087364
2029	5643.486211	1493.7	3778.192549
2030	6094.965108	1506.3	4046.315547
2031	6460.663015	1518.9	4253.514395
2032	6848.302795	1531.5	4471.630947
2033	7259.200963	1544.1	4701.250543
2034	7694.753021	1556.7	4942.990313
2035	8156.438202	1569.3	5197.500925
2036	8645.824494	1581.9	5465.46842
2037	9164.573964	1594.5	5747.616158
2038	9714.448402	1607.1	6044.706864
2039	10297.31531	1619.7	6357.544796
2040	10915.15422	1632.3	6686.978021
2041	11570.06348	1644.9	7033.900831

TIME	**cars**	**cars / 1000 people --- (V)**
2001	5297219	4.93
2002	5748036	5.26

2003	6594166	5.93
2004	7267174	6.43
2005	8072650	7.03
2006	9109855	7.82
2007	10146468	8.58
2008	11200142	9.33
2009	12365806	10.16
2010	13749406	11.14
2011	15467473	12.37
2012	17569546	13.88
2013	20503389	16.01
2014	21671515	16.72
2015	23807986	18.17
2016	25638424	19.36
2017	27612583	20.64
2018	29744000	22

We assumed the saturation level of Cars per 1000 people to be 250.

It is assumed by looking at data of other Asian developed countries who have already reached the saturation level.

YEAR	**Y(i) = LN(LN(V*/V))**	**[Y(i) - Y(bar)]**
2001	1.367652152	0.232671804
2002	1.351011656	0.216031307
2003	1.319469683	0.184489335
2004	1.297596029	0.162615681
2005	1.272922454	0.137942106
2006	1.242648089	0.10766774
2007	1.215514049	0.0805337
2008	1.19034818	0.055367831
2009	1.164088644	0.029108295

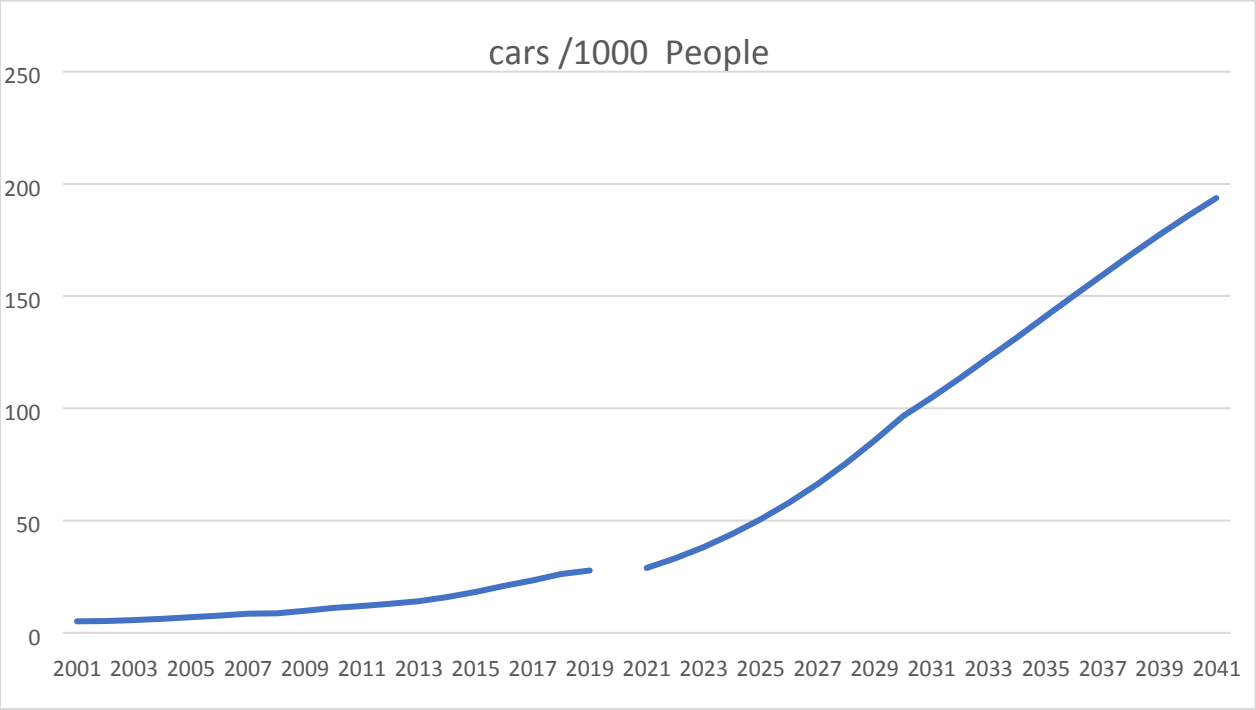
2010	1.134918079	-6.22695E-05
2011	1.100672409	-0.03430794
2012	1.061606601	-0.073373748
2013	1.010963396	-0.124016953
2014	0.995048421	-0.139931928
2015	0.96381878	-0.171161569
2016	0.939324149	-0.1956562
2017	0.913980055	-0.221000293
2018	0.88806345	- 0.246916899
Average (Y -bar) =	1.134980349	
saturation limit (V*) =	250	

YEAR	gdp per capita(US $) ----- (X(i))	X(i) - X(bar)	[Y(i) - Y(bar)] * [X(i) -X(bar)]		[X(i) - X(bar)] ^2
2001	851.6167442	-510.993344	-118.893743		261114.1977
2002	869.4537969	-493.1562913	-106.5371981		243203.1277
2003	922.177238	-440.4328503	-81.25516351		193981.0956
2004	979.1076487	-383.5024395	-62.36351018		147074.1211
2005	1040.432206	-322.1778819	-44.4418954		103798.5876
2006	1106.821107	-255.7889814	-27.54022161		65428.00301
2007	1173.935091	-188.674997	-15.19469557		35598.25447
2008	1192.736965	-169.8731234	-9.405506463		28856.87805
2009	1267.964195	-94.64589343	-2.754980576		8957.845144
2010	1357.854654	-4.755433768	0.000296119		22.61415032
2011	1410.061585	47.45149699	-1.627963097		2251.644567

2012	1469.42645	106.8163614	-7.837516757		11409.73507
2013	1544.106167	181.4960788	-22.5085906		32940.82663
2014	1639.660494	277.0504056	-38.76819729		76756.92724
2015	1751.70782	389.0977315	-66.59857806		151397.0446
2016	1876.132931	513.5228423	-100.4739279		263705.7095
2017	1982.810164	620.2000762	-137.0643988		384648.1345
2018	2090.976331	728.3662431	-179.8459338		530517.3841
	X (bar) =	1362.610088			
			beta =	- 0.00044	
			Log(- alpha)	1.735874	
			alpha =	-5.67389	

year	cars /1000 People
2001	5.1
2002	5.2
2003	5.7
2004	6.3
2005	6.9
2006	7.7
2007	8.5
2008	8.7
2009	9.8
2010	11.1
2011	11.9
2012	12.9
2013	14.1

2014	15.9
2015	18.2
2016	20.9
2017	23.4
2018	26.2
2019	27.8
2020	
2021	28.9
2022	33.2
2023	38.2
2024	44
2025	50.6
2026	58
2027	66.3
2028	75.5
2029	85.6
2030	96.4
2031	104.8
2032	113.5
2033	122.5
2034	131.6
2035	140.9
2036	150.2
2037	159.4
2038	168.5
2039	177.3
2040	185.7
2041	193.7



Hence by 2030 there will be 96 cars per 1000 people,

And by 2041 there wiil be 194 cars per 1000 people.

year	2 W	2 W / 1000 people -- (V)	Y(i) = LN(LN(V*/V))	[Y(i) - Y(bar)]
2001	38556026	35.8660707	0.880320616	0.421191015
2002	41581058	38.04305398	0.855583169	0.396453568
2003	47519490	42.7525776	0.804704234	0.345574633
2004	51921973	45.96491944	0.771767059	0.312637458
2005	58799702	51.23710526	0.720276123	0.261146522
2006	64743126	55.54965766	0.680156766	0.221027165
2007	69128762	58.42525524	0.654258887	0.195129286
2008	75336026	62.74864734	0.61644297	0.157313369
2009	82402105	67.67028414	0.574823785	0.115694184
2010	91597791	74.21031435	0.521505233	0.062375631
2011	101865000	81.47244661	0.464488236	0.005358635
2012	115420000	91.1834413	0.391089764	-0.068039838

2013	132550000	103.4738486	0.301692692	-0.15743691
2014	139410000	107.5694444	0.272564308	-0.186565294
2015	154298000	117.7712476	0.201078199	-0.258051402
2016	168975000	127.6246224	0.133106128	-0.326023473
2017	186565000	139.435725	0.052460378	-0.406669224
2018	206765000	152.9326923	-0.039295408	-0.49842501
2019	227946000	166.7490856	-0.133560712	-0.592690313
		average (Y-bar) =	0.459129601	
		saturation limit (V*) =	400	

We assume the saturation limit will be 400 two wheelers per 1000 people.

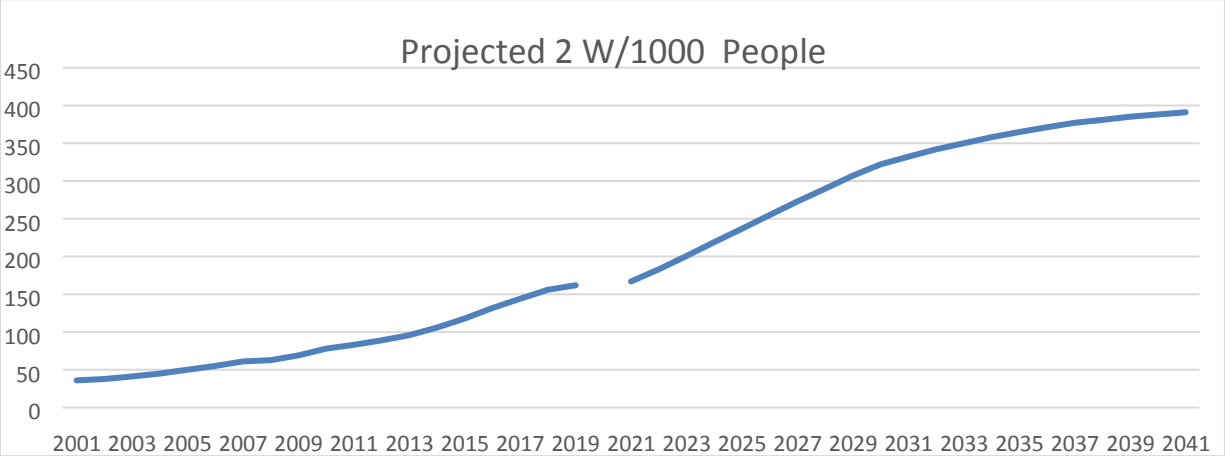
We assumed it by looking at the data of various developed Asian countries.

year	gdp per capita(US $) -- (X(i))	X(i) - X(bar)	[Y(i) - Y(bar)] * [X (i) - X(bar)]	[X(i) - X(bar)] ^ 2
2001	851.6167442	-552.5099963	-232.7122461	305267.296
2002	869.4537969	-534.6729436	-211.972996	285875.1566
2003	922.177238	-481.9495025	-166.5495224	232275.323
2004	979.1076487	-425.0190918	-132.8768883	180641.2284
2005	1040.432206	-363.6945342	-94.97756251	132273.7142
2006	1106.821107	-297.3056337	-65.71262126	88390.63982
2007	1173.935091	-230.1916492	-44.91713207	52988.19537
2008	1192.736965	-211.3897756	-33.25443773	44685.63725
2009	1267.964195	-136.1625457	-15.75321459	18540.23885
2010	1357.854654	-46.27208604	-2.886250574	2141.105946
2011	1410.061585	5.934844722	0.031802666	35.22238187
2012	1469.42645	65.29970918	-4.442981625	4264.052019
2013	1544.106167	139.9794266	-22.03792835	19594.23986
2014	1639.660494	235.5337533	-43.94242389	55476.14896
2015	1751.70782	347.5810792	-89.69378484	120812.6066
2016	1876.132931	472.00619	-153.8850975	222789.8434

2017	1982.810164	578.6834239	-235.3327388	334874.5051
2018	2090.976331	686.8495909	-342.343014	471762.3605
2019	2151.426481	747.2997408	-442.9173176	558456.9027
Average (X-bar) =		1404.12674		
			beta =	-0.000752756
				1.516093845
			alpha =	-4.554400211

year	Projected 2 W/1000 People
2001	36
2002	38
2003	41
2004	45
2005	50
2006	55
2007	61
2008	63
2009	69
2010	78
2011	83
2012	89
2013	96
2014	106
2015	118
2016	132
2017	144
2018	156
2019	162
2020	
2021	167
2022	183
2023	201

2024	219
2025	237
2026	255
2027	273
2028	290
2029	307
2030	322
2031	332
2032	342
2033	350
2034	358
2035	365
2036	371
2037	377
2038	381
2039	385
2040	388
2041	391



Hence by 2030 there will be 322 two wheelers by per 1000 people.

And by 2041 there will be 393 two wheelers per 1000 people i.e we will near our saturation limit.

year	vehicles	vehicles / 1000 people -- (V)	Y(i) = LN(LN(V*/V))	[Y(i) - Y(bar)]
2001	54991026	51.15444279	0.961734728	0.321755405
2002	58924337	53.91064684	0.941471946	0.301492622
2003	6700284	6.028145749	1.559121168	0.919141844
2004	72717935	64.37494246	0.869767462	0.229788138
2005	85101719	74.15625566	0.808663607	0.168684284
2006	89618267	76.89254998	0.792391132	0.152411809
2007	96707260	81.7336545	0.764357687	0.124378363
2008	105353854	87.75100283	0.730720886	0.090741563
2009	114951033	94.40012565	0.694914583	0.05493526
2010	127745972	103.4966961	0.647909537	0.007930214
2011	141956000	113.537551	0.598257601	-0.041721722
2012	159500000	126.0072681	0.539261901	-0.100717423
2013	176000000	137.392662	0.487498057	-0.152481266
2014	190700000	147.1450617	0.444468759	-0.195510564
2015	210000000	160.28699	0.388057429	-0.251921894
2016	230000000	173.7160121	0.331932292	-0.308047031
2017	253300000	189.3124066	0.268255905	-0.371723418
2018	278630000	206.0872781	0.201127426	-0.438851898
2019	306500000	224.2136064	0.129695038	-0.510284285

		average (Y-bar) =	0.639979323	
		saturation limit (V*) =	700	

We will now predict the total number of vehicles owned per 1000 people till the year 2041.

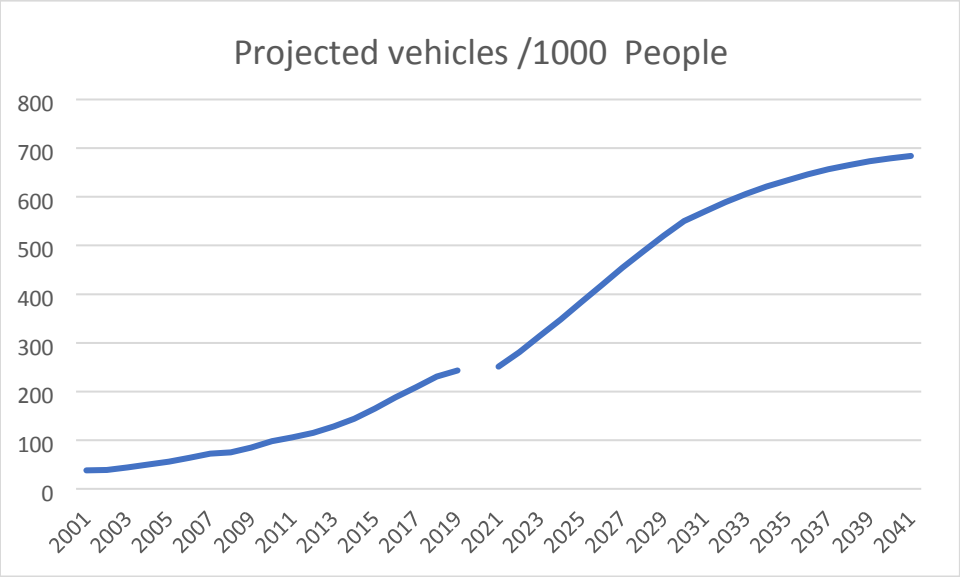
We will take the saturation limit to be 700 vehicles per 1000 people, as observed from other developed nations.

year	gdp per capita(US $) -- (X(i))	X(i) - X(bar)	[Y(i) - Y(bar)] * [X (i) - X(bar)]	[X(i) - X(bar)] ^ 2
2001	851.6167442	-552.5099963	-177.7730774	305267.296
2002	869.4537969	-534.6729436	-161.1999479	285875.1566
2003	922.177238	-481.9495025	-442.9799545	232275.323
2004	979.1076487	-425.0190918	-97.66434583	180641.2284
2005	1040.432206	-363.6945342	-61.34955199	132273.7142
2006	1106.821107	-297.3056337	-45.3128894	88390.63982
2007	1173.935091	-230.1916492	-28.63086057	52988.19537
2008	1192.736965	-211.3897756	-19.18183864	44685.63725
2009	1267.964195	-136.1625457	-7.48012482	18540.23885
2010	1357.854654	-46.27208604	-0.366947528	2141.105946
2011	1410.061585	5.934844722	-0.247611943	35.22238187
2012	1469.42645	65.29970918	-6.57681841	4264.052019
2013	1544.106167	139.9794266	-21.3442402	19594.23986
2014	1639.660494	235.5337533	-46.04933695	55476.14896
2015	1751.70782	347.5810792	-87.56328395	120812.6066
2016	1876.132931	472.00619	-145.4001056	222789.8434
2017	1982.810164	578.6834239	-215.1101804	334874.5051
2018	2090.976331	686.8495909	-301.4252463	471762.3605
2019	2151.426481	747.2997408	-381.3353139	558456.9027
Average (X-bar) =		1404.12674		
			beta =	-0.000779985
				1.73517762

			alpha =	-5.66993481

year	Projected vehicles /1000 People
2001	38
2002	39
2003	44
2004	50
2005	56
2006	64
2007	72
2008	75
2009	85
2010	98
2011	106
2012	115
2013	128
2014	144
2015	165
2016	188
2017	209
2018	231
2019	243
2020	
2021	251
2022	281
2023	314
2024	348
2025	383
2026	419
2027	454
2028	487
2029	520
2030	550
2031	570
2032	589
2033	606
2034	621

2035	634
2036	646
2037	657
2038	665
2039	673
2040	679
2041	684



We come to the conclusion that by 2030 there will be 550 vehicles per 1000 people.

And by 2041 we will attain the near saturation limit of 684 vehicles per 1000 people.

Petrol in Delhi costs Rs 86.95 , diesel costs Rs 77.13 and the electricity charges in Delhi range between Rs 3/unit to Rs 8/unit depending on the usage. So, for this example, we'll settle for the average at Rs 5.5/unit. For an EV, we'll take an average range of 120 km while we take the average mileage of a petrol vehicle at 16 kmpl and a diesel vehicle at 18 kmpl. We consider an average commute of 40 km/day for the vehicles.

	Range/Mileage	Total electricity usage (charging)	Electricity usage/Fuel consumption (Units/litres per commute)	Cost of running per day	Cost of running per month (30 days)
EV	120	20 units approx.	0.166 units	Rs 36.52	Rs 1095.6
Petrol vehicle	16	-	2.5 litres	Rs 217.37	Rs 6521.1
Diesel vehicle	18	-	2.22 litres	Rs 171.22	Rs 5136.6

The cost of running of an EV is around 84% less than the petrol counterpart and around 80% less than the diesel counterpart.

Low cost of maintenance:

Lithium-ion battery costs are reducing and India is gearing towards serious investment in high-performance batteries. Currently, EV batteries, for instance, have up to 90% capacity after driving 241,000 kms.

The typical Indian driver doesn't even complete the distance which is given above, and for those who even complete the target, EV companies give them a guarantee of 1,60,000 km/eight years of the battery.

An internal combustion vehicle requires servicing of several movable parts in a timely manner. On the other hand, the only scheduled service for an EV is the change of coolant after every 10,000 kilometres.

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Thank You !